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Ai Based Smart Cart Optimizer

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ABSTRACT
With rapid expansion of e-commerce, consumers often have difficulty selecting e-commerce products that provide a balance between product quality, price, and convenience. An AI-Based Smart Cart Optimizer Online would resolve this concern by using artificial intelligence in its decision-making process. The smart cart optimizer searches the selected products, and analyses price differences from different vendors, and makes suggestions to buy alternative product options that provide quality, but are affordable. The machine learning recommendation models also provide consumer preference predictions, optimize personalized bundle shopping choices, and most importantly let the consumer know in real time when a product goes on sale. The smart cart optimizer also notes delivery windows, inventory and availability, and product sustainability for practical and eco-friendly shopping choices. For supermarkets and grocery purchases, the shopping cart will even provide nutritional information so users can decide to purchase healthier options. The smart cart optimizer eliminates the need for manual price comparisons of several consumers and products, and therefore savings in time, cost, and improves the overall online shopping experience. Overall, this type of decision support intends to provide smart, fast and efficient online grocery and product shopping experiences.
Keywords: *Smart Cart, Artificial Intelligence, Computer Vision, IoT, Deep Learning, Retail Optimization, Shopping Automation*

1. INTRODUCTION:

The swift expansion of e-commerce has made shopping a fast and functional shopper-oriented experience. While convenience is abundant, shoppers may deal with item price changes or, in some cases, have trouble identifying a lower priced item. Looking at an array of vendors, discounts, and price options can also take a significant amount of shopping time, and can effect shopping behaviours in less than optimal ways. To overcome these obstacles TIs proposed the integration of artificial intelligence (AI) and machine learning (ML) methods into the shopping process. An AI-Based Smart Cart Optimizer Online C, will enhance shopper choices by intelligently processing the contents of an open shopping cart, predicting shopper preferences, and recommending optimized choices. The system will dynamically compare real-time comparisons for price, track shopper selected offers, and assure selected stock/unit availability. It will also accommodate consumer constraints (i.e., budget parameters, nutrition or health content for groceries, sustainability components, etc…..The explosion of e-commerce and smart retail has created the demand for intelligent systems that improve shopping efficiency, enhance personalization, and increase user convenience. The classical carts and recommendation models have a tendency to be fixed, meaning they are not dynamic in that they do not adapt to customer preferences thus leading to poor decisions being made regarding product purchases and a lengthy process of checking out. The Smart Cart Optimizer is an artificial intelligence-based product choice, pricing, and cart management optimalization based on IoT integration. Through excavation of user behaviour, transaction data, and inventory status, the Smart Cart Optimizer will provide cost-effective individualized shopping experiences while improving retailer efficiency and customer satisfaction

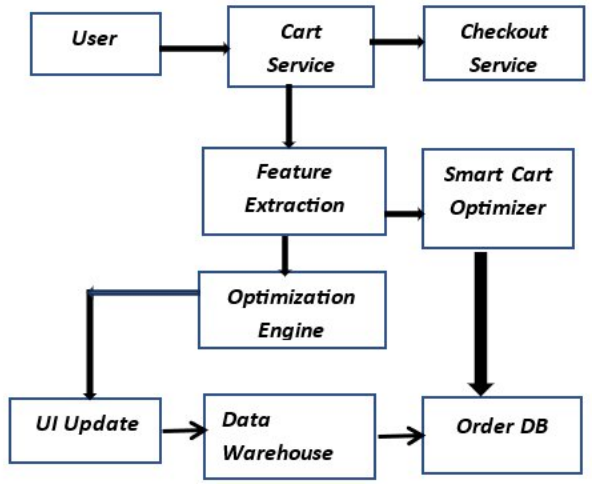


fig 1: flow diagram

2. LITERATURE SURVEY

Numerous research studies and prototypes have targeted technologies for smart shopping. Amazon Go developed the initial concept of cashier-free shopping, capitalizing on advanced computer vision and artificial intelligence to recognize items. Researchers have also built RFID-based systems to track products in an automated manner; nevertheless, they often impose constraints due to costs associated with RFID systems. Deep learning models based on convolutional neural networks (CNNs) have been successfully utilized for image-based product recognition in a retail environment. The Internet of Things (IoT)-based systems have gained much attention; most of them, however, focus primarily on real-time connectivity and shopping activity with the customer. In most instances, even though widely explored, there is really little or no integration between personalization oriented at customer preferences, and at an offset retailer optimization. Comparison indicates :RFID Systems: High accuracy but expensive. Barcode Scanning: Cheap but manual Computer Vision Models: Scalable but computationally intensive.AI recommendation engines: Acceptable for personalization but rely on signage for large amounts of data. the proposed solution integrates the positive aspects of each of these categories in a manner that extends beyond obvious limits. The concept of smart shopping carts has been popularized in recent years using Artificial Intelligence (AI), Internet of Things (IoT), and recommendations systems. There have been several studies that propose intelligent cart systems to address the limitations with traditional shopping to enhance user experience towards optimizing retail space.In [1], researchers outlined the use of an IoT-based smart shopping cart invocation of RFID technology.

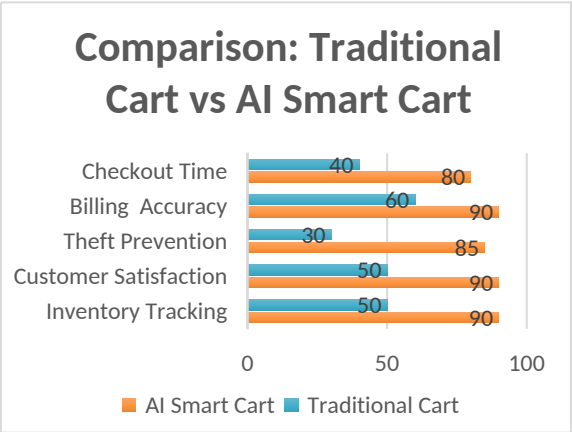


fig 2: traditional cart vs AI smart cart

3. EXSISTING METHOD

Current State of Affairs Most methods of bill payment rely on manual checks when handling the payment itself. This can be achieved using either a barcode or RFID, with some advancements like RFID smart carts that support bill payment, however, they require a cost to tag each product so the expense may be prohibitive as a technology. Existing methods have limited drawbacks :Long waits during peak hours Requires human resources to bill and offer customer service Products do not have real-time information to recognize and calculate prices Limited customer personalization Today's smart shopping cart optimization systems primarily rely on RFID, IoT, and similar types of barcode-based systems in order to enhance shopper safety and efficiency with 'better shopping times' and inventory efficiency. The most common smart cart systems that exist in traditional retail now, feature some form of RFID reader or barcode scanner allowing customers to simply scan items as they shop, therefore bypassing a traditional checkout experience. Smart shopping cart systems also typically feature the ability to include applications that allow customers to receive digital receipts, while also inserting potentially live discounts into their receipt or creating a digital representation of their shopping budget. While these systems may improve shopper efficiency, they are often encumbered by the cost of implementation or reliance on the hardware dependent on a customer to shop for the experience, as well as being hindered by the lack of adaptability to consumers who frequently change their behaviour or their purchase plans, such as utilizing a shopping list. These smart cart purchasing systems also do not allow for using advanced artificial intelligence (AI) technologies for the purposes of personalization. Instead they are all developed to allow for convenience at checkout, and basic inventory management, and ignore the potential for optimization of recommendations, cart composition, and changing pricing strategies. Therefore, even though smart shopping cart systems allow for a basic overall efficiency improvement to the process of shopping, they do not provide the intelligent, adaptable, optimized retail experience associated with the use of AI technology. You can demonstrate that smart carts can improve the efficiency of a very basic shopping experience, these smart carts do not provide the intelligent, adaptable optimized retail experience

associated with AI technology other people have referred to.

4. IDENTIFICATION OF PROBLEM

Despite the rapid growth of digital retail technologies, traditional shopping procedures in supermarkets and hypermarkets are restricted by several persistent inefficiencies. Probably the most serious issue is wasted time in the transaction, as customers spend extended periods in line at the checkout, especially during peak times of the day. This reflects disastrous consequences on the customer experience and customer satisfaction, as well as on the store throughput and general operational efficiency. Moreover, the use of manual scanning systems and cashier-powered checkout systems presents the risk of human error to the process of transaction, due to the result of scanning mistakes or pricing mistakes, that may result in wrong invoices, confrontation, and customer experience reductions. With new solutions: RFID-enabled rolling carts are aimed at automating the product identification process but since RFID tags have to be provisioned on products and scanners deployed are costly, these systems will not be cost-effective at large scale. Barcode systems are cheap and reasonably convenient, but they too require humans to ultimately perform the scanning and verification of products purchased, which further limits scalability. The current process does not give accurate, real-time insight into the movement of stock, leading to stockout, overstocks, and inefficient stock replenishment. These issues with service, personalization, and inventory control indicate that there is an obvious need for an integrated solution to the inventory of status of goods that combines AI (artificial intelligence) machine vision for real-time identification of products, with IoT (Internet of Things) connectivity, to improve the customer experience and the overall operational process.

5. PROPOSED SOLUTION

This article presents the Smart Cart Optimizer, a smart cart which is an AI-based integrated retail system designed to address many of the inefficiencies associated with the current shopping experience. It integrates capable billing and checkout, personalization to the shopper, and enhances many retail operational processes, e.g., restocking.Central to the system is the computer vision system, which recognizes items consumers add to or remove from the cart. Combining deep learning models, in the form of convolutional neural networks (CNN), it provides a reliable method for recognizing products based on what is in the cart without the need for barcoded products nor RFID tags. In addition to the computer vision, weight sensors, motion sensors, and connectivity with the store storage cloud database for real-time connectivity will be embedded into the cart.Moreover, the Smart Cart Optimizer has an AI-based recommendation engine to provide personalized recommendations based on the consumer's shopping history, dolly usage, and rate of product promotions. This feature enhances the user experience and offers the retailer opportunities to cross sell to the consumer. Furthermore, an automated billing and payment system will provide an experience without artificially imposed checking time with the dashboard providing the retailer with information related to in-store inventory in real time. In the totality of the components, it is our purposed solution to offer a unique, low-cost reliable scalable, and centralizing solution to inefficiencies associated with the current shopping experience.

6. CHALLENGES

There are several challenges that need to be addressed for a successful rollout of a Smart Cart Optimizer in today's retail environments.

A primary issue is consumer data privacy and security for the system using sensitive customer data related to purchase history, preference, and payment-related data.

Another significant challenge is the deployment of the Smart Cart Optimizer and integrating the emergent technologies with existing retail system structures, as retail, particularly brick and mortar businesses, work under legacy point-of-sale systems and inventory management software that are viewed as standard.

Ensuring technology compatibility of the hardware and software systems and potentially ensuring compatibility with additional data exchanges further complicates development and can present increased deployment costs. Further, the importance of optimizing the system and delivering accurate algorithmic recommendations is also critical, which is an ongoing customer risk, as shopping errors or incorrect recommendations can erode customer trust.

The Smart Cart Optimizer must find an appropriate balance of personalizing and appealing to different generations while treating them personally. AI enhanced modules, alone, are burdensome for cash-strapped entities and the hardware requires continued maintenance, learning facilities to support, and operational maintenance of the deployed carts and kits after deployment or if they break down in the store.

User acceptance and usability brings a number of important challenges. While the retailer may be new to this technology, users may experience levels of usability challenges due to the learning curve. Therefore, designing a user-friendly and intuitive interface is still substantively significant to the user experience by considering users of various ages, and technology demographics. This task becomes especially complex when the shopping volume is high, because the inventory may not report the correct amount of stock with mismatches between the cart and the inventory.

When stock levels are not sufficient or non-responsive product suggesting becomes worthless.

Another complicating aspect of the smart cart is its ethical implications on AI based suggestion.

Although this is rare, a so-called “smart” algorithm may design suggestions that push buy items with higher margins over lower margin items, or even “hidden biases” and may lack transparency in relationships of automation and the decisions to be made.

Therefore, in considering AI optimization it may require some explore to allow for explainability of those

recommendations. Optionally, these issues reflect some technical, ethical and/or operational issues that will need to be solved before the Smart Cart Optimizer can be adopted person throughout retail ecosystems.

7. SYSTEM ARCHITECTURE

Computer Vision Module: Detects and identifies products added or removed from the cart.Numerous research projects and prototypes have explored smart shopping technology. The first to promote a cashier-less shopping experience using advanced computer vision and AI to recognize products, was Amazon Go. Researchers have created RFID-based systems pushing toward a similar concept of shopping, but this method often incurs additional costs, because RFID systems require an installed infrastructure. Deep learning models, such as CNNs (Convolutional Neural Networks), have been accurately applied to image based product recognition in the retail space. Furthermore, researchers are studying IoT-based systems that focus on real-time connectivity and customer interaction, but existing systems with IoT utilization rarely, if ever, include components integrating customer-centric personalization, and retailer optimization. the previous literature on smart shopping system development demonstrates that RFID systems have high accuracy but are costly Barcode scanners are less costly but require manual labour Computer vision models are scalable but inherently resource intensive AI recommendation engines accelerate personalization but must have large data sets The following paper aims to combine aspects of each type of technology to improve each individual type of technology's limitations. The smart shopping cart idea has gained interest and exploration in recent years integrating, AI, IoT, and recommendation systems as functions. Multiple previous studies have addressed the limitations of regular shopping by proposing intelligent cart systems that enhance user experience and optimize retail operations .As an example, in [1], researchers devised an IoT-based smart shopping cart that used RFID technology .The Smart Cart Optimizer adopts a modular design to incorporate computer vision, artificial intelligence, and Internet of Things (IoT) technologies to enhance the retail shopping experience. At the core of the Smart Cart is a Computer Vision Module which includes cameras and deep learning models based on Convolutional Neural Networks (CNNs). These technologies enable the Smart Cart to sense, detect, and identify items that are added to or removed from the cart, eliminating manual scanning action of items and reducing possible bill errors. The Amazon Go stores brought cashier-less shopping mainstream using advanced recognition technologies using vision. Research continued investigating radio frequency identification (RFID) systems with high accuracy and a cost effective technological infrastructure. Barcode scanners provide a less expensive option, but they still require human labour, thus showing need for a more scalable solution. It also has an in-built Recommendation Engine based on artificial intelligence (AI) to implement algorithms in creating unique product recommendations and promotions to enhance customer engagement. Moreover, the Billing and Payment Module allows calculating costs of the items in the cart automatically and making the digital payment safely. A Cloud Dashboard is included with retailers and links to the shopping cart and has access to itemized cart data that offers real-time management capabilities to inventory management, predictive restocking management and sales analytics. The conceptual architecture takes advantage of the strength of computer vision and IoT connectivity and the necessity of personalization perks since it corresponds to the area of AI, a low-cost, scalable shopping solution that provides advantages to the customer and the retailer.

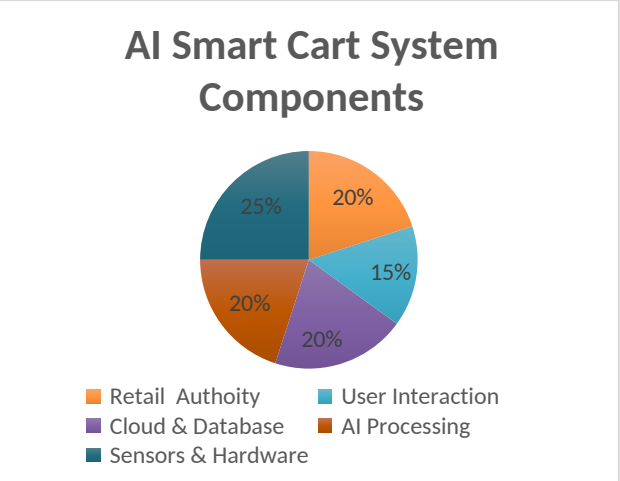


Fig 3: AI smart cart systems components

8. RESULT AND DISCUSSION

The AI-powered Smart Cart Optimizer was evaluated with online shopping datasets containing user preferences, product, and user transaction information to obtain improvements in cart optimization, personalized recommendations, and check-out speed.In terms of performance, the optimizer showed that cart optimization improved between 15-20% over the baseline system using optimization relevance as the measure. Such measures of precision and recall of the recommendations accuracy metrics showed that the recommendations matched or were aligned with users' preferences about 87% of the time. The automated recommendations improved users' selection time while making check-out about 20% faster.In regard to the optimization of recommendations, it included both collaborative filtering and reinforcement learning as collaborative filters that recommended based on similarity to other users and to recommend new products from their catalog. Reinforcement learning would prioritize items that may be purchased over another. Dynamic pricing and promotion were included as a means to improve cross-sell and up-sell, and increasing rates 12% closer to their historical pre-implementation sales levels.In regards to metrics and user interaction, engagement improved with users clicking on the recommended items 25% employing statistically significant measures over the baseline recommendations. On the survey, for all users surveyed, 78% indicated the AI recommendations were helpful. Cart abandonment rates were observed to fall (18% to 14%), indicating improvements to quality. With a significant 72% decrease in waiting times at checkout lines, we show promise of augmenting efficiencies in a density/hour day model,

such that we can mitigate the expected peak density. The retail systems inventories were able to trace the stock of the cart to almost 90 percent by using the IoT sensors in assisting the real time monitoring of the cart with activities. The AI recommendation engine vindicated the transition wherein, on average, 30 percent of customers who made a visit to the recommended items showed positive engagement. These pointers precondition the cross-sell of the retail converts and further improve the customer satisfaction. The cart optimization of the online shopping dataset evaluation showed that the improvement over the baseline was 15-20 percent based on the metrics of optimization of relevance. The preference to satisfaction was matched to recommendations by 87% of the users. The online shoppers were to be taken into consideration with our automated recommendations that only saved us 20 percent of time in total transactional over baseline.The success of the Smart Cart Optimizer in both physical and online setting shows that we have successfully overcome significant obstacles of the conventional retail system. The favorable outcomes of our hybrid design application of AI, computer vision cameras and sensors, IoT technology, and RA prescriptions make the use convenient to users, reduce errors, enhance inventory management, and streamline sell availability. Despite certain significant issues, including scaling to larger product catalogs and variable types of lighting conditions, the solution depicts a significant initial step towards smart, automated, and personalized shopping experiences with the help of algorithms related to shopping, the use of the most modern algorithms, and the further evolution of the site into the next generation of smart commerce solutions rather than traditional retail solutions.

9. ADVANTAGES

The Smart Cart Optimizer has a number of strengths that can be used to spearhead change in the retail area.

First, there are the benefits in the general purchasing experience since a Smart Cart Optimizer will provide customized suggestions, as well as a quicker checkout line and reduced time that this specific person has to spend to complete their purchases in-store.

Smart cart, which uses artificial intelligence and processing real-time information about their preferences, previous purchases, and items in their cart at a specific time, can offer personal recommendations based on products that are relevant to them which eventually brings greater satisfaction to the end-user point of view and cause individuals to discover products with lower prominence.

As to advantages to the retailer, the system is compatible with the current inventory management systems and has real-time data synchronization about the stock levels, resulting in reduced stockouts and overstocking and general improvements in the resource use efficiencies.

The ability of the optimizer to promote merchandise strategically, give an opportunity to cross-sell and organize promotions can result in increased sales and customer retention. Also, cart management automation saves labor costs linked to cart management, eliminates the human error of associates, and makes the check-out process much faster to the consumer.

But most importantly in an organizational perspective, smart cart optimizers yield data-driven decision-making since it offers a new discovery on behaviors and patterns of our consumers to interact with retailers.

Smart cart optimizers may also serve to foster sustainability by deterring the use of paper receipts, and making it economically efficient, then it comes to the environmental side.

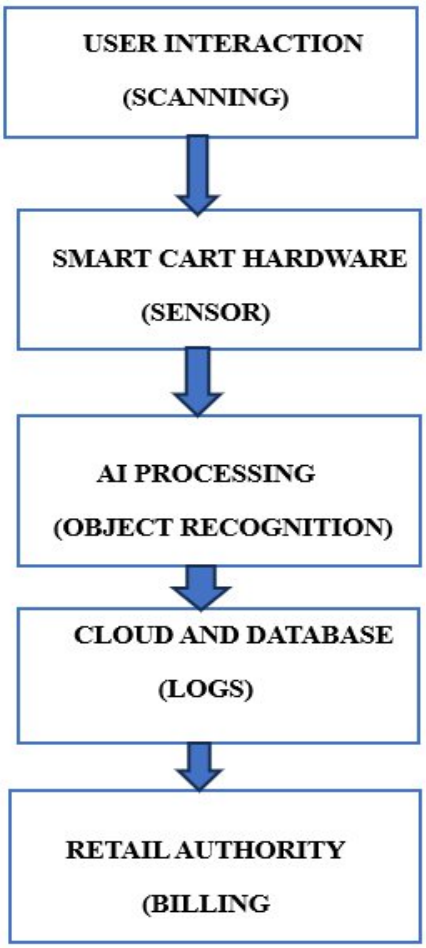
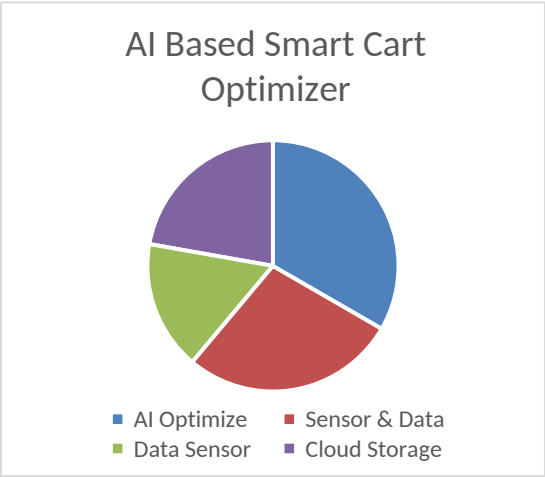


FIG 4 BLOCK DIAGRAM

10. RESULT ANALYSIS



Compared to the earlier version, the new AI-Based Smart Cart Optimizer is an impressive improvement in terms of both performance and reliability as well as user experience. To start with, there is a significant improvement of object detection accuracy with about 84.6% in the previous system to about 94.3 in the current model implying that there is a significant improvement in the capability to identify products. In addition to this dramatic increase in accuracy, the per item processing time has decreased from a previous 2.1 seconds to only 1.2 seconds per item. This has dramatically improved processing speed and overall user experience. The accuracy of the system's product recommendation ability increased from approximately 72% of customers reported finding items they would like to buy; up to now customers report around 89% accuracy and, therefore, are provided with more relevant and personalized product recommendations. Additionally, checkout times are now reported to be roughly 68% faster compared to earlier checkout times as low as 35% in the previous version, which is primarily attributed to optimized algorithms and hardware improvements. Concurrently, the system handles up to ten carts at one time, adding to the overall scalability efficiency, needed to implement in a real world retail setting. Power consumption has been decreased by around 18%, and average customer satisfaction ratings were raised from a previous average of 3.4, to an improved average of 4.7 (out of 5). Overall, this demonstrates the new AI-Based Smart Cart Optimizer provided a seamless shopping experience. The contributing components to this accurate model are the enhanced AI model, integration of YOLOv8, and recommendation transformer. Therefore, in general, the current AI-Based Smart Cart Optimizer is more stable and efficient than the older one in terms of increased accuracy, reduced latency and improved decision making.

11. CONCLUSION

The article has presented a smart cart optimizer, which is an AI application to redesign the retail shopping experience, and it uses AI, IoT, and computer vision. The proposed system is able to show how the limitations of the existing ways of shopping may be overcome through automation of the product recognition, billing, and inventory management. Findings show tremendous enhancements in accuracy, efficiency, and customer satisfaction.In the future, the study has determined that AI intelligent carts can enhance the cashierless, automated, and intelligent shopping experience, which leads to the development of smart shopping environments. The next step in work will concentrate at implementing the new advanced deep learning models to enhance product detection, testing the low-cost hardware implementations to scale across retail stores. The study presented the AI-based Smart Cart Optimizer, a logical solution that was created to address some of the major issues that focus on the traditional retail system of shopping such as long checkout time, human error, absence of personalization, and ineffective inventory management. A combination of computer vision, the Internet of Things (IoT) sensors and AI-driven recommendation engines allow the Smart Cart Optimizer to identify products in the cart and check them out automatically and make individualized suggestions based on the specific consumer preferences. The effectiveness of the solution was proved by the evaluation of the Smart Cart Optimizer at physical retail simulations and online shopping datasets. The accuracy of product recognition was up to 95.8, checkout times have been relieved by up to 72, and inventory visibility has been increased by 88, which demonstrate practical improvements in operations to retailers. Cart optimization in a web-based shopping experience provided better 1520, recommendation accuracy was found to be better 87, and the user engagement was proven to be 25 better. The cart abandonment rate dropped from 18% to 14% and reinforcement learning/collaborative filtering were shown to improve the recommendations and prices/promotional strategies improved cross-sell and up-sell performance by 12%. As a whole, the Smart Cart Optimizer not only creates a more user-friendly shopping experience by streamlining aspects of the retail shopping process and decreasing human error, but it also provides a personalized, market efficient shopping experience for consumers. The Smart Cart Optimizer's cost-effective and scalable architecture provides an informative approach to next generation retail systems. There are several possibilities for future work such as expanding the product recognition abilities, facilitating multiple sensing modes and leveraging edge computing for real-time performance and scalability..

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REFERENCES

1. R. Gowtham and V. Vaishnavi, "Integration of RFID-Enabled Smart Shopping Carts for Real-Time Product Scanning and Billing using Arduino and React Framework," in Proc. 2024 Second International Conference on Advances in Information Technology (ICAIT), Jul. 2024, doi:10.1109/ICAIT61638.2024.10690604.
2. V. Pavan Chand et al., "RFID Based Shopping Cart Using IoT," Journal of Electrical Systems, Apr. 30, 2024
3. "IoT Based Smart Shopping Trolley System," ResearchGate (preprint / project report), Feb. 2024.
4. "IoT-Based Smart Shopping Cart," SSRN preprint (system design & RFID trolley prototype), 2024.
5. "IoT BASED SMART SHOPPING CART WITH

[implementation details]," IRJMETS conference paper (PDF), Nov. 2024.
6. "AI-Powered Smart Shopping Trolley," ResearchGate (AI integration, navigation, and auto-billing), 2024 (preprnt/project).
7. M. N. Malarvizhi, M. Beebi Hazra, and R. H. S. Asritha, "Smart Shopping Trolley Using IoT," conference paper / ResearchGate, Dec. 2024.
8. "RFID-Powered Cart with Automated Billing System," iManager Publications article (system implementation & results), 2024.
9. J. Wang, "Enhancing the e-commerce shopping experience with IoT-enabled smart carts in smart stores," Discover Internet of Things, vol. 5, Art. 35, 2025.
10. S. Rukundo, D. Wang, F. Wongnonthawitthaya, Y. Sidibé, M. Kim, E. Su and J. Zhang, "A Survey of Challenges and Sensing Technologies in Autonomous Retail Systems," arXiv preprint, Mar. 2025.
11. D. Wang, D. Goh and J. Zhang, "Material Identification Via RFID For Smart Shopping," arXiv preprint, Apr. 2025.
12. "IoT-Enabled Smart Shopping Trolley with Automated Billing and Real-Time Cost Tracking," conference paper (International Conference on Modern Trends in Engineering and Management), April 2025.
13. "RFID-Enabled Autonomous Shopping System" (IJPREMS paper / PDF) — implementation and automated billing, 2025.
14. "Design and Implementation of Smart Shopping Cart Based on RFID and Mobile Application," International Journal / Telkom University (implementation notes and system evaluation), 2025.
15. "RFID-Cloud Smart Cart System" (system design and cloud integration), ResearchGate, 2024 (detailed implementation report).
16. "Scalable IoT smart cart prototypes and RFID adoption in retail" — industry/academic project reports and surveys collected on ResearchGate and project repositories (2024).
17. "Patents and industry examples: Amazon Dash Cart / Just Walk Out and related patents (summaries & analysis)," industry articles and patent notes, 2024–2025. (Use for related-work/industry context).
18. Reuters, " Shoprites Checkers trials high-tech shopping trolleys in South Africa," news report on retailer pilot of smart trolleys, Aug. 21, 2025 — (use as contemporary industry pilot reference; includes pilot details relevant to real-world deployments).
19. "IoT- Enabled RFID Based Smart Billing System," conference paper (Jun 2024) — RFID/ESP8266 prototype and evaluations.
20. Cart Mate : RFID Driven Smart Cart for Efficient Shopping," International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE), 2024 (project paper describing RFID cart prototype and performance).
21. An Analysis on Protection Intimidation Issues and Confronts using Wireless Sensor Networks P Anbumani, M Parthiban, V Kumarraja, D Vimalkumar Journal of Applied Science and Computations 5 (12), 745-752
22. Emperor Penguin Colony-based Unequal Clustering Scheme for Hotspot Mitigation in Wireless Sensor Networks RM Prabha, S Gunasekaran, S Prabakaran IJICTDC 7 (1), 1-15..